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GUIDE ON HUMAN SAFETY IN DESIGN, MANUFACTURE, USE AND MAINTENANCE OF ELECTRONIC EQUIPMENT

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Indian Standard

GUIDE ON HUMAN SAFETY IN DESIGN, MANUFACTURE, USE AND MAINTENANCE OF ELECTRONIC EQUIPMENT

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GUIDE ON HUMAN SAFETY IN DESIGN, MANUFACTURE, USE AND MAINTENANCE OF ELECTRONIC EQUIPMENT

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 10 July 1986, after the draft finalized by the Reliability of Electronic and Electrical Components and Equipment Sectional Committee had been approved by the Electronic and Telecommunication Division Council.

0.2 This standard has been prepared with a view to highlighting essential areas of hazards to human safety requirements for consideration by the designers, manufacturers, users and maintenance authorities. Some of these safety measures may be incorporated in detail in the relevant product specifications. In such cases, the provisions of this standard may be taken as additional guidance related to use and maintenance. Elementary guidelines to aviod mishaps and for first-aid are given in Appendix A.

1. SCOPE

1.1 This standard identifies essential areas of hazards to human safety in design, manufacture, use and maintenance of electronic items.

2. TERMINOLOGY

2.1 For the purpose of this standard, the following terms and definitions shall apply.

2.1.1 Safety — Safety means freedom from those conditions that may cause death, injury or occupational illness to human beings.

2.1.2 Hazard — An existing potential condition that may result in a misharp.

2.1.3 Mishap — An unplanned event or series of events that may endanger human safety.

2.1.4 Fail-Safe — The design feature of a part, unit or equipment which causes the item to fail in a non-hazardous mode.

3. GENERAL

3.1 The design and development of all electronic equipment shall provide fail-safe features for safety of personnel during installation, operation, maintenance and repair or replacement of a complete equipment, assembly or component parts thereof. The equipment design for personnel safety shall meet the requirements as specified in the relevant Indian Standards.

3.2 Human engineering factors affecting safety should also be considered when establishing general or detailed design criteria. Rigorous detailed operational or maintenance procedures are not acceptable substitutes for an inherently safe design. Specific human safety requirements which are to be observed during the manufacturing and operational phases of an equipment shall also be considered at the design stage.

3.3 The quantitative values indicated for voltages, currents, noise level, etc, are only recommended features. In practice, they have to be tailored for an equipment, based on technology and other factors applicable to the equipment.

4. SAFETY FROM ELECTRICAL HAZARDS

4.1 Safety Through Design — The design shall incorporate methods to protect personnel from accidental contact with voltage in excess of 30 volts rms or dc during normal operation of an equipment. Means shall be provided so that power may be cut-off while installing or repairing the equipment. Personnel shall be protected from capacitor discharges while replacing fuses or any other component. The main power switch on the equipment should be clearly marked with ON-OFF position and should be capable of disconnecting power to all parts of the equipment.

4.2 Hazardous Factors — Current rather than voltage is the most important variable in establishing safety of the personnel. The following factors cause severity of an electric shock and, therefore, should be controlled:

a) Quantity of current flowing through the body;

b) Path of current through the body;

c) Duration of current flowing through the body;

d) Nature of current, ac or dc; and

e) Area of contact.

The voltage necessary to produce the fatal current is dependent upon the resistance of the body, contact conditions and the path through the body. Table 1 enlists probable affects of shock.

TABLE 1 PROBABLE EFFECTS OF SHOCK

(*Clauses* 4.2 *and* 4.5)

CURRENT VALUES, mA		EFFECTS
ac (50 Hz-1 kHz)	*dc*	
(1)	(2)	(3)
0-1	0-4	Perception
1-4	4-15	Surprise
4-21	15-80	Reflexe action
21-40	80-160	Muscular inhibition
40-100	160-300	Respiratory
Over 100	Over 300	Usually fatal

NOTE — For tropical environment, like in India, the safe current limit is 300 µA.

4.2.1 Sufficient current passing through any part of the body will cause severe burns and haemorrhages. However, relatively small currents can be lethal if the path includes a vital part of the body, such as heart or lungs. Electrical burns are usually of two types, those produced by heat of the arc which occur when the body touches a high voltage circuit, and those caused by passage of electrical current through the skin and tissue. There are various methods of incorporating adequate safeguards for personnel, many of these methods being implicit in routine design procedures. While current is the primary factor which determines shock severity, protection requirements of this standard are based upon the voltage involved to simplify their application. All voltages expressed in this standard apply to dc value or the rms value for ac.

4.3 Protective Measures — Most of the electrical hazards can be avoided by proper design and fabrication of the equipment. This includes grounding, shielding, terminations, connections, etc, and are discussed below.

4.3.1 *Ground Potential* — The design and construction of the equipment shall ensure that all external parts, surfaces and shields exclusive of antenna and transmission line terminals remain at ground potential at all times during operation. The design shall include consideration of ground faults. The voltage limits shall be on the basis of hazardous location. Plugs and outlets for use with metal case portable tools and equipment, shall have provisions for automatically grounding the metal frame or case of tools and equipment when the plug is mated with receptable and the ground pin shall make first and break last.

4.3.2 *Grounding* — Ground connection to shields, hinges and other mechanical parts shall not be made to complete electrical circuits. A point on the electrically conductive chassis or equipment frame shall serve as the common tie point for the static ground, power ground and when applicable, return leads in mobile and air-borne systems. All ground points in an equipment shall be connected individually to main ground connection of chassis. The path from the tie point to ground shall:

a) be continuous and permanent;

b) have ample current carrying capacity to conduct safely any fault currents that may be imposed upon it;

c) have impedance sufficiently low to limit the potential above ground and to facilitate the operation of over current devices in circuits;

d) have sufficient mechanical strength to minimize the possibility of disconnection; and

e) be protected against corrosion.

Resistance between ground terminal and exposed metal parts should be low. This value should be specified in the equipment specification and in any case should not be more than 0·2 ohms when measured with a current of 10 amperes.

4.3.2.1 Unused wires installed in line, within conduits or cables, shall be grounded to allow for stray or static electricity discharge. Panels and doors shall be attached or hinged in such a manner that they maintain the same ground potential as the associated equipment in both closed and open position. A flexible ground strap may be used for this purpose.

4.3.2.2 Ground connection to an electrically conductive chassis or frame, shall be mechanically secured by soldering to a welded terminal lug or to a portion of chassis or frame that has been formed into a soldering lug, or by use of a terminal on the ground wire and then securing the terminal by a screw, nut and a lock washer/nut. The grounding terminal and metal around that should be made corrosion resistant.

4.3.2.3 Shielding on wires or cables shall be grounded to the chassis in above manner. The shielding shall be secured to prevent contact with exposed parts and chassis at any point other than the ground termination. The shielding shall end at a sufficient distance from exposed conductor to prevent shorting or arcing between conductors and shield.

4.3.3 *Guards and Barriers* — All contacts, terminals and like devices having voltages between 70 and 500 volts rms or dc with respect to ground shall be guarded from accidental contact by personnel, if such points are

exposed during operation or maintenance. Open terminals should be adequately recessed to prevent accidental contacts. Test probe holes may be provided in the barriers or guards where maintenance testing is required. The assemblies operating at potential above 500 volts dc or rms shall be completely enclosed from rest of the parts and interlocked in accordance with **4.3.4.** Terminations and connections which are permanent may be protected by permanent insulation provided they are not required to be exposed during normal maintenance.

4.3.4 *Interlocks* — Equipment sub-assemblies operating in excess of 500 V shall be considered guarded against accidental contact only if they are completely enclosed from remainder of the equipment and are separately protected by non-bypassable interlocks. An example of equipment where such compartmentalization is desirable is a display unit which utilizes a high voltage power supply for a cathode ray tube. Modularized or sealed high voltage assemblies which are not required to be opened during use, maintenance or equipment repair, may be exempt from interlocks. When a unit is provided with access doors, covers and plates these access points shall be interlocked as follows:

a) No interlocking is required if all the parts operating above 70 V are protected by guards and barriers to prevent accidental contact in all conditions of use and maintenance;

b) By passable locks are required if parts operating between 70 and 500 V become exposed when access doors, or covers, or panels are opened. Such internal points are allowed to be unguarded when they are not accessible during operation and routine maintenance.

c) Non-bypassable interlocks are required if parts operating above 500 V become exposed to accidental contact at any time.

4.3.5 *Shorting Rods* — Shorting rods shall be provided with all transmitting equipment operating at voltages in excess of 70 V rms or dc.

Whenever size permits, shorting rods shall be stored within the transmitting equipment, and be permanently attached and readily accessible to maintenance personnel. The permanently attached rod shall be connected through a flexible stranded copper wire (covered with a transparent sleeving) to the stud provided at the transmitter main frame.

A grounding stud shall be provided in all other transmitting equipment to permit attachment of a portable shorting rod. The connection to the stud shall be such that accidental loosening or high resistance to the ground shall be prevented. The location of storing the shorting rod can also be interlocked with the main system as a precautionary measure.

4.3.6 *Discharging Devices* — Discharging devices shall be provided to discharge high voltage circuits and capacitors unless they themselves get discharged to 30 V or less within 2 seconds. These protective devices shall be positive acting, highly reliable, and shall actuate automatically when the case or rack is opened. Shorting bars should be actuated either by a mechanical release or an electrical solenoid when the door or cover is open. When resistive bleeder networks are used to discharge capacitors, the bleeder network shall consist of at least two equal valued resistors in parallel, each capable of discharging the capacitor to 30 V or less with 2 records.

4.3.7 *High Voltage Test Point Protection* — When the operation or maintenance of equipment employing potentials in excess of 300 volts peak could require that these voltages be measured, the equipment shall be provided with test points so that these voltages can be measured at relatively low potential level, but in no case shall the potential exceed 300 volts peak relative to ground. This may be accomplished through the application of voltage dividers or other techniques such as the use of safety-type panel meters and multipliers. Test points with voltages above 30 volts shall have the conducting material recessed a distance no less than the diameter of the probe hole and a minimum of 2·0 mm. If a voltage divider is used, the voltage divider resistance between the test point and ground shall consist of at least two equal valued resistors in parallel. Full details should be given in instruction book or maintenance manual as to the method used in the equipment to obtain the voltage at the test points.

4.3.8 *High Current Protection* — Power sources capable of supplying high current can be hazardous, regardless of the voltage at which they operate because of arcing and the heat generated if accidentally short circuited. All power buses supplying 25 amperes or over shall be protected against accidental short circuiting by tools, jewellery or removable conductive assemblies. This may be accomplished by one or more of the following:

a) Use of guards and barriers,

b) Sufficient space separation to prevent short circuits, and

c) Caution warning signs.

4.3.9 *Connections for External Power* — Application of power to externally powered test equipment or portable electronic equipment shall meet the following requirements:

a) Power shall be controlled by a power ON-OFF switch located on the front pannel. An indicator lamp shall be provided to indicate 'power on' to the test set, except for low-power battery operated equipment.

b) Neither side of the supply voltage shall be directly connected to the chassis.

c) A conductor intended for use as a grounding conductor shall have a continuous identifying marker readily distinguishing it from the other conductor or conductors. It shall either be green coloured or green coloured with one or more yellow stripes.

4.3.10 *Electrical Connectors* — Connectors used to provide separation of or connection to multiple electric circuits shall be selected so that it will be impossible to insert the wrong plug in a receptacle or other mating unit. Where design considerations require plug and receptacles of similar configuration in close proximity, the mating plugs and receptacles shall be suitably coded or marked to clearly indicate (polarized) the mating connections. The design of the connector shall be such that the operator is not exposed to electrical shock or burns when normal disconnection methods are used. Exposed pin contacts shall not be energized (hot) after being disconnected. In any case, connectors associated with ac/dc power supply should not be used for any other purpose.

4.3.11 *Insulation of Controls* — All control shaft and bushings thereof shall be grounded, whenever practicable. Alternatively, the control knobs or levers and all attachment screws that can be contacted during use shall be electrically insulated from the shaft.

4.4 Bonding in Hazardous Areas — Electronic equipment to be installed in areas where explosive or fire hazards exist, shall be bonded as per the requirements indicated by the corresponding agencies.

4.5 Applicable Protective Measures — The protective measures required for different voltage ranges are suggested as follows:

a) 0-70 V — Although no specific requirements exist, the design shall be reviewed for possible hazards in accordance with Table 1.

b) 70-500 V
   - i) Guards and barriers
   - ii) Caution markings
   - iii) Bypassable interlocks
   - iv) Automatic discharge devices
   - v) Shorting rods

c) 500 and above
   - i) Enclosures
   - ii) Danger markings
   - iii) Non-bypassable interlocks
   - iv) Automatic discharge devices
   - v) Shorting rods

5. RADIATION PROTECTION

5.1 Ultrasonic and Sonar Equipment — The hazards due to ultrasonic equipment are similar to hazards due to noise which have been covered later. The ultrasonic equipment is not hazardous, if used as directed. However, ultrasonics are known to disintegrate human cells and enzymes. Some workers using ultrasonic cleaners and drills may complain of headache and nausea. Persons with hearing problems or nerve disorders shall not be employed around ultrasonic equipment.

TABLE 2 ACCEPTABLE SOUND PRESSURE LEVELS FOR ULTRASONIC CLEANERS

a) Frequency range 175 to 5 600 Hz

Octave Band Centre Frequency, Hz	*Octave Band Sound Pressure Level*, dB
250	94
500	88
1 000	85
2 000	84
4 000	84

b) Frequency range 5 600 to 18 000 Hz

Centre Frequency of the One-Third Octave Band, Hz	*One-Third Octave Band Sound Pressure Level*, dB
6 300	80
8 000	80
10 000	80
12 500	80
16 000	80

c) Frequency range 18 000 to 45 000 Hz

Centre Frequency of the One-Third Octave Band, Hz	*One-Third Octave Band Sound Pressure Level*, dB
20 000	105
25 000	110
31 500	115
40 000	115

NOTE — All sound pressure levels are expressed in decibels (dB) reference 0·000 2 dynes per square centimetre (0·000 2 microbar).

These are the maximum acceptable octave band levels, when measured at the head position (ears) of the operator, at the normal operator's position by the ultrasonic cleaner, and when the cleaner is the source of the sound. The sound pressure level of each octave band shall be at least 10 dB lower when measured at any position about the cleaner located within a radius length of 4·5 metre from the position of the centre of the operator's head.

5.2 rf Radiation (High Frequency Range) — The radiation hazards in the HF and VHF range equipment are not well established compared to those in the microwave region. However, with the use of high power broadcast and UHF stations, the hazards will be limited to areas very near to the source of radiation. The permissible maximum allowable full time exposure can be taken between 10 W/m to 20 W/m.

5.3 Microwave, Radio Frequency (rf), X-Ray Laser Radiation Limits

5.3.1 *Microwave and rf Radiation* — Microwave and rf radiation either due to direct exposure or by leakages should be limited so as not to affect the human body in view of the biological effects.

5.3.1.1 Biological hazards to personnel due to whole-body radiation are measured by incident power density or energy flux, respectively in milliwatts or millijoules per square centimetre. Biological damage to living tissue is known to be caused by the heating effect on the tissue. (Some other reversible effects are known or suspected, but are not considered here). Skin burns, eye cataract and overheating of delicate body organs can be caused by radio frequency (rf) radiation. Organs with limited circulation to dissipate heat, such as lungs, testicles, and liver, may be damaged by rf radiation. At present, the generally accepted threshold level is a time-averaged power density of 100 milliwatts per square centimetre (100 mW/cm^2), for a limited duration of 6 minutes during any hour period, over the frequency range from 10 MHz to 100 GHz.

NOTE 1 — Personnel with implanted prosthetics are exposed to additional hazards, indirectly from rf emissions interfering with their operation and, therefore, they should not be allowed to expose themselves to intense rf radiation.

NOTE 2 — In certain countries, the limits for exposure are as low as 10 $\mu W/cm^2$ and 1 $\mu W/cm^2$.

5.3.1.2 The following safety precautions are only indicative, and not exhaustive:

a) Do not enter denied occupancy areas unless the transmitters have been and remain switched off;

b) Do not look into or inspect any device, feedhorn, open waveguide, reflectors, radiatiors, etc, while operating;

c) Use fencing or other structure to keep non-operating and test personnel out of danger; and

d) Erect rf screens or shields to protect personnel who must approach high power installation with suitable radiation warning signs at such locations.

5.3.2 *X-Radiation* — All electronic and electrical devices capable of producing X-radiation shall be so designed, fabricated, shielded and operated as to keep personnel exposure as low as reasonably achievable. For equipment and installation design, shielding requirements shall be maintained at all times which limit the radiation levels is not greater than 2 milliroentgens (mr) in any one hour and 100 mr in any 7 consecutive days at the operator position or within 5 cm from the equipment (whichever is closer) in any unrestricted area accessible to personnel.

5.3.3 *Laser Radiation* — In view of the fact that laser radiation is specially coherent, human hazard is more prone for biological effects to the eyes as well as to the skin. In addition, the following hazards are also likely:

a) Electrical shock from system producing laser, and

b) Toxic chemicals utilized with the laser work or exploding components such as flash tubes or optics, cryogens for cooling and noise or bright flash levels with laser, which may startle personnel working in the area and thereby cause an accident. The hazards are different for different types of lasers.

5.3.3.1 The following precautions, in addition to the protective devices of the equipment are to be used for personnel safety:

a) Avoid looking into the primary beam at all times;

b) Do not aim the laser with the eye; direct reflection could cause eye damage;

c) Do not look at reflection of the beam; these too could cause retinal burns;

d) Avoid looking at the pump source at all times;

e) Clear all personnel from the anticipated path of the beam;

f) Do not depend on sunglasses to protect the eyes. If laser safety goggles are used, be certain that they are designed to be used with the laser being used. Inspect safety goggles before each use. Determine failure point of goggles either from the manufacturer or test them at their highest intended power before using. (It is best to completely enclose the laser, the beam and the target and not having to use the safety goggles).

g) Report any afterimage to a physician, preferably an ophthalmologist who has had experience with retinal burns, as damage may have occurred;

h) Be very cautious around lasers that operate at invisible light frequencies; and

j) Before operation, warm all personnel and visitors of the potential hazard. Remind them that they have only one set of eyes.

6. MECHANICAL HAZARDS

6.1 Mechanical Hazards — The design of the equipment shall be such as to provide maximum access and safety to personnel while installing, operating and maintaining the equipment. Suitable protection shall be provided to prevent contact with moving mechanical parts such as gears, fans and belts when the equipment is complete and operating. Sharp projections on cabinets, doors and similar parts shall be avoided. Doors or hinged covers shall be rounded at the corners. Doors, hinged covers and rack mounted equipment shall be provided with stops to hold them in each operating and maintenance configuration. Equipment design shall include provisions to prevent accidental pulling out of drawers or rack mounted equipment components which could cause equipment damage and injury to personnel. Equipment power switches shall be so designed and located that accidental contact by personnel will not place equipment in operation.

6.2 Mechanical Interconnection — The design shall provide means to prevent the inadvertent reversing on mismating the fittings, couplings, mechanical linkages, instrument lids and electrical connections, specially for items involving explosives and emergencies for safety critical systems. Where mismating by design consideration is not feasible, coding and marking shall be employed.

6.3 Cathode Ray Tubes — Provision in accordance with IS 6568-1972* shall be incorporated to protect personnel from injury due to implosion of cathode ray tubes.

6.4 Glass Fibres — Glass fibre materials shall not be used as outer covering on cables, wires or other items where they may cause skin irritation to operating or maintenance personnel or where there is any evidence of glass protruding from the surface.

6.5 Thermal Hazards — Where people are involved and under any condition of operation, exposed parts including the enclosure of the equipment, shall not achieve a temperature in excess of 60°C at an ambient temperature of 25°C. The temperature of front panels and operating controls shall not exceed 49°C at the same ambient temperature.

7. SAFETY CONSIDERATIONS AGAINST LIGHTNING

7.1 Since India is situated in tropical zone with thunderstorms, there is a possibility of lightning hazards at exposed installations of electronic equipment. Proper protective measures are to be adopted for the safety of the operating personnel.

*Implosion protection for TV picture tubes.

7.2 Lightning Protection for Exposed Installations — All exposed installations which are liable for lightning hazards should be properly grounded and provided with necessary alternate arrangements as specified by relevant Indian Standard guidance specifications on the subject. These protective devices should also be maintained during their life to ensure that the protection is not vitiated. These apply to antennas, supported structures, high raised buildings and high tension electrical towers.

7.3 Lightning Protection to Personnel Operating Electronic Systems — There are certain situations where the hazard due to lightning may be transferred to the operating personnel who, even though externally protected, are susceptible to such hazards. Such personnel include operating personnel in the telephone exchange, power supply systems and electrical communication systems. To protect the operating personnel, protective devices like lightning arrestors/fusable links are to be installed in the system, so that in addition to protect the equipment from damage, the personnel working on such systems are not exposed to sudden high voltages due to lightning.

8. HAZARDOUS AND RESTRICTIVE SUBSTANCES

8.1 Certain chemical substances used in electronic industry are hazardous to the operating personnel. When such chemicals are to be used, care should be taken for adequate protection to personnel coming into contact with them.

8.2 Certain chemical fumes likely to be generated in electronic industry are hazardous. Wherever such fumes are likely to occur, suitable exhaust systems should be provided. Care should also be taken by wearing protective masks and goggles while working in such environments.

8.3 The following materials are representative samples, used during the manufacture/maintenance of electronic equipment:

a) Cadmium used in electroplating and soldering and also in alkaline batteries;

b) Mercury used in switching/operating and other temperature indicating devices;

c) Trichloroethylene, used as cleaning and de-greasing liquid, is hazardous when the vapours are inhaled:

d) Freon or sulphur hexafloride used in pressurizing wave guides of high power equipment;

e) Nematic liquid, used in liquid crystal devices, is hazardous to the skin;

f) Lithium batteries used in watches;

g) Radioactive materials — Use of radioactive materials shall conform to the codes approved by the Atomic Energy Commission. (Radiation Protection Rules, 1971 issued under the Gazette of India, May 18, 1982);

h) Asbestos — Special care is to be taken when handling items utilizing asbestos since asbestos fibres are carcinogens (cancer producing substance);

j) Lead in any form, either in batteries or in soldering; and

k) Beryllium oxide, used in rf transistors and certain heat sink washers, is harmful in the form of dust.

9. HAZARDS DUE TO STATIC ELECTRICITY

9.1 In electronic equipment industry, static electricity has got hazardous effects, both on personnel as well as the product. Generally, in industry, accumulation of static charges within the human body does not cause adverse effects during manufacture/operation, but in hazardous environment, static discharge in the form of arcing may cause fire and explosion. These are more relevant for persons working in the storage of explosive materials or electro-explosive gadgets. In the manufacture of electronic equipment, MOSFET devices are susceptible to static electricity build up. Precautions shall be taken in accordance with IS : 10087-1981*.

9.2 Protecting personnel or product against electrostatic discharge by personnel is only one part of the overall concept. For complete protection of both equipment as well as personnel, the following may be taken into consideration:

a) Conductive work surface,

b) Conductive floor mats,

c) Wrist straps of conductive material,

d) Conductive seats and tools for operation,

e) Conductive tool boxes,

f) Conductive foam,

g) Conductive bags for shipment of static sensitive devices,

h) Special soldering irons and solder suckers,

j) Mask used while soldering, and

k) Production of ionized air which will discourage build up of static electricity by blowing air across the area.

*Code of practice for handling of electrostatic sensitive devices.

10. SAFETY AGAINST NOISE AND HAZARDS DUE TO NOISE

10.1 At any intensity, noise can be irritating and adversely affecting the human health and output. This is more so where the environment has high intensity noise developed. Protection against acoustic noise hazards is therefore, required in testing areas of electronic equipment and also in factories during fabrication stages. Protection against noise hazard can be classified as under:

a) Suppression of noise at the source by having noise mufflers and acoustic treatment, and

b) Suppression of noise input to the human beings by providing ear muffs.

10.2 The permissible noise exposure values are given below:

Duration Per Day, h	*Sound Level Slow Response*, dBA
8	90
6	92
4	95
3	97
2	100
1	102
1	105
1/2	110
1/4	115

NOTE — When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered rather than the individual effect of each. If the sum of various fractions : $C_1/T_1 + C_2/T_2 + \ldots C_n/T_n$ exceeds unity, then the mixed exposure should be considered to exceed the limit value; C_n indicates the total time of exposure at a specified noise level and T_n indicates the total time of exposure permitted at that level; dBA is the weighted noise level to 'A' category of equivalent noise level of 40 phones.

11. HAZARDS DUE TO UNDERGROUND INSTALLATIONS

11.1 Hazards to operating personnel may happen when electronic equipment is installed in mines as well as in underground installations. The following areas are likely to be hazardous for personnel with regard to underground installations:

a) Accidental ignition of gas due to electric sparks or relay contacts in explosive atmosphere in a mine. Care is, therefore, to be taken that such equipment used in mines should have safety precautions as indicated by the relevant agencies.

b) Hazards may also happen when cables are laid for electronic systems while digging up earth and on accidental contact with other installations like gas pipes, electrical cables or telephone installations.

c) There are some situations where persons working with electronic system have to carry out underground installations in ducts which can accumulate toxic fumes under natural or man-made conditions.

11.2 The above are indicative of such situations due to underground installations which can be avoided by taking precautionary measures which will not aggravate situation, in consultation with the appropriate agencies.

12. MARKING, SIGNS, TAGS AND SYMBOLS

12.1 Marking — Doors, gates, barriers, covers and panels shall be marked to indicate the hazards which may be open on removal of such devices. When feasible, marking shall be located in such a way that it is not removed when the doors are being removed. It is preferable to adopt a colour code to indicate physical hazards. The marking shall be so placed as to be visible to the operator or maintenance personnel even when the units are opened for repair or replacement.

12.2 Signs — In accordance with the existing regulations, suitable signs for danger, caution, etc, shall be used to warn against physical hazards and other hazardous parameters such as voltages, current, thermal, etc. The marking of such signs shall remain permanent for the normal life expected of equiment to which they are fixed. Specific marking for special applications are to be used where necessary and the areas where such special markings are called for, are as below:

a) High power microwave or radio frequency source,

b) Laser hazard signs,

e) Nuclear source signs,

d) Radiation source signs, and

e) Use of luminous paints for safety during power failure.

APPENDIX A

(*Clause* 0.2)

PRECAUTIONS TO AVOID MISHAPS AND FIRST-AID GUIDANCE

A-1. The operating personnel may observe following precautions to avoid mishaps in operating areas:

a) While working on energized circuit, precuations should be taken to ensure that body does not become conductive.

b) Do not depend on switches to de-energize the circuit. Pull the plug from the outlet.

c) If working in high voltage circuit or in the field, have a second person as standby to help in case of shock or any other accident. The helper should at least know how to de-energize the circuit and the fundamentals of first aid.

d) Do not wear loose clothings, metallic frame on eye glasses, rings, watch or other jewellary which are likely to get entangled with the operation.

e) When mentally and physically fatigued, avoid working on electrical circuits.

f) Never assume that the circuit is dead, check first before working.

g) Care should be taken to discharge static charges by suitable means before removing protective dielectric covers from range surfaces.

A-2. The following are the fundamental first-aid actions in brief:

a) Cardiac pulmonary resuscitation (CPR) (artificial respiration) is necessary when a person is unconscious after the shock hazard and this is to be done immediately after removing the person from the scene of accident;

b) If foreign matter is visible in the mouth, wipe it out quickly with fingers, wrapped in a cloth, if possible.

c) Tilt the victim's head backwards so that his chin is pointing upwards. This is accomplished by placing one hand under the victim's neck and lifting it and the other hand on his forehead and pressing it. This procedure should provide an open airway by moving the tongue away from the back of the throat.

d) Maintain the backward head-tilt position and to prevent leakage of air, pinch the victim's nostrils with the fingers of the hand that is pressing on the forehead;

e) Open your mouth wide; take a deep breath and seal your mouth tightly around the victim's mouth with a wide open circle and blow into his mouth. If the airway is clear, only moderate resistance to the blowing effort will be felt;

f) If you are not getting air exchange, check to see if there is a foreign body in theback of the mouth obstructing the air passage. Reposition the head and resume the blowing effort;

g) Watch the victim's chest and when you see it rise, stop inflation, raise your mouth, turn your head to the side and listen for exhalation. Watch the chest to see that it falls; and

h) When his exhalation is finished, repeat the blowing cycle for a total of six breaths. Volume is important. Start at a high rate and then provide at least one breath every five seconds for an adult.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2